How does marijuana use affect school, work, and social life?
See page 7.

NIDA NATIONAL INSTITUTE ON DRUG ABUSE

Research Report Series

Marijuana Abuse

from the director:

By the time they graduate from high school, about 42 percent of teens will have tried marijuana. Although current use among U.S. teens has dropped dramatically in the past decade (to a prevalence of about 14 percent in 2009), this decline has stalled during the past several years. These data are from the Monitoring the Future study, which has been tracking drug use among teens since 1975. Still, the World Health Organization ranks the United States first among 17 European and North American countries for prevalence of marijuana use. And more users start every day. In 2008, an estimated 2.2 million Americans used marijuana for the first time; greater than half were under age 18.

The use of marijuana can produce adverse physical, mental, emotional, and behavioral effects. It can impair short-term memory and judgment and distort perception. Because marijuana affects brain systems that are still maturing through young adulthood, its use by teens may have a negative effect on their development. And contrary to popular belief, it can be addictive.

We hope that this *Research Report* will help make readers aware of our current knowledge of marijuana abuse and its harmful effects.

Nora D. Volkow, M.D.
Director
National Institute on Drug Abuse

What Is Marijuana?

Marijuana—often called *pot, grass, reefer, weed, herb, Mary Jane,* or *MJ*—is a greenish-gray mixture of the dried, shredded leaves, stems, seeds, and flowers of *Cannabis sativa*—the hemp plant. Most users smoke marijuana in hand-rolled cigarettes called *joints*, among other names; some use pipes or water pipes called *bongs*. Marijuana cigars, or *blunts*, are also popular. To make blunts, users slice open cigars, remove some of the tobacco, and mix the remainder with marijuana (Timberlake 2009). Marijuana also is used to brew tea and sometimes is mixed into foods.

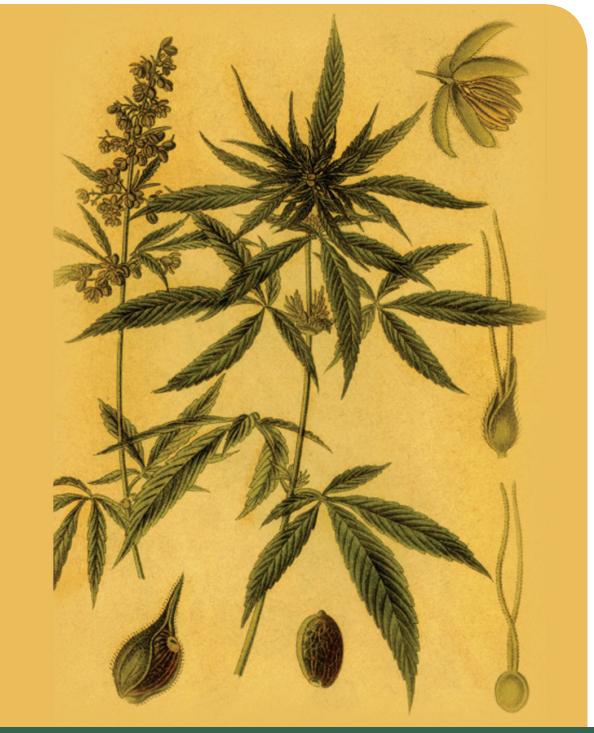
continued inside

Marijuana Abuse

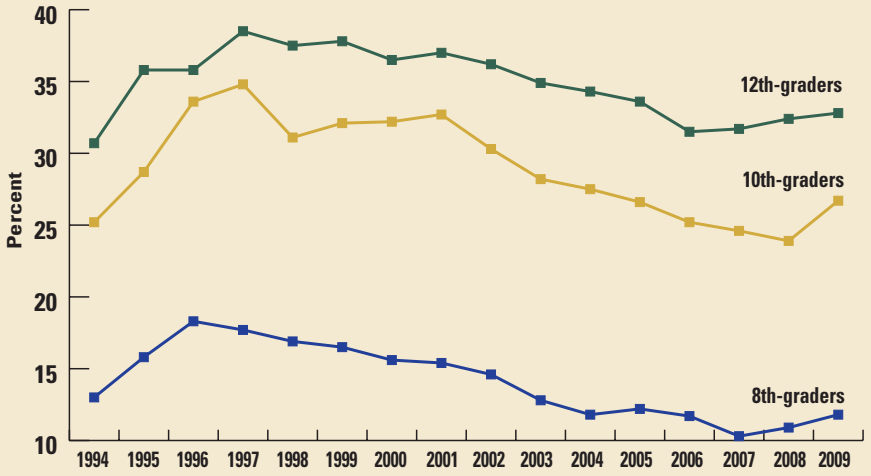
What Is the Scope of Marijuana Use in the United States?

Marijuana is the most commonly used illicit drug (15.2 million past-month users) according to the 2008 National Survey on Drug Use and Health (NSDUH). That year, marijuana was used by 75.6 percent of current illicit drug users (defined as having used the drug some time in the 30 days before the survey) and was the *only* drug used by 53.3 percent of them.

Marijuana use is widespread among adolescents and young adults. According to the Monitoring the Future Survey—an annual survey of attitudes and drug use among the Nation's middle and high school students—most measures of marijuana use decreased in the past decade among 8th-, 10th-, and 12th-graders. However, this decline has stalled in the past few years as attitudes have softened about marijuana's risks. In 2009, 11.8 percent of 8th-graders reported marijuana use in the past year, and 6.5 percent were current users. Among 10th-graders, 26.7 percent had used marijuana in the past year, and 15.9 percent were current users. Rates of use among 12th-graders were higher still: 32.8 percent had used marijuana during the year prior to the survey, and 20.6 percent were current users.



Long-Term Trends in Annual* Marijuana Use Among 8th, 10th, and 12th Graders



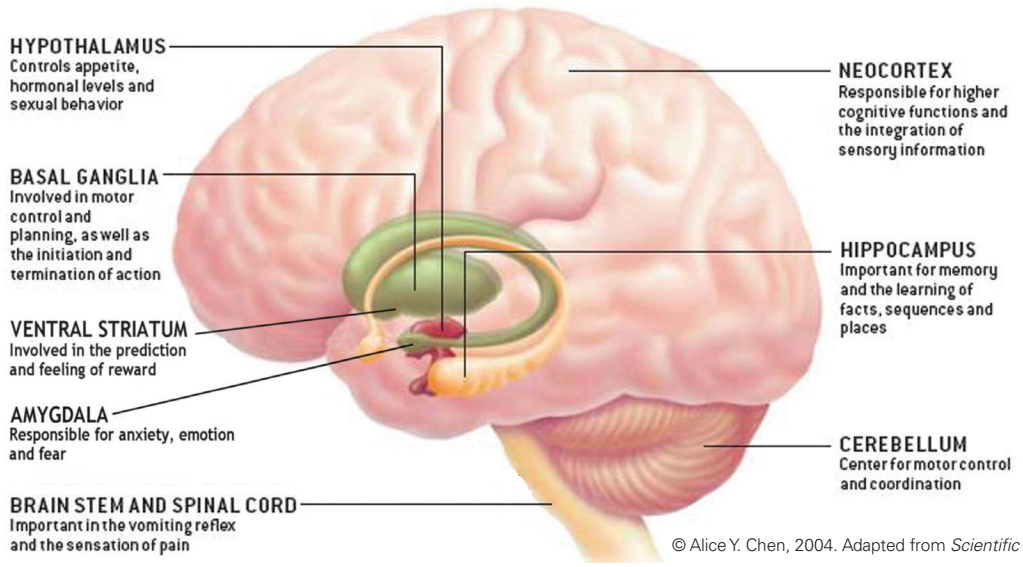
*use in the past 12 months
Source: 2009 Monitoring the Future Survey

The Drug Abuse Warning Network (DAWN), a system for monitoring the health impact of drugs, estimated that in 2008, marijuana was a contributing factor in over 374,000 emergency department (ED) visits in the United States, with about two-thirds of patients being male, and 13 percent between the ages of 12 and 17.

How Does Marijuana Produce its Effects?

Delta-9-tetrahydrocannabinol (THC) is the main active ingredient in marijuana, responsible for many of its known effects. When marijuana is smoked, its effects begin almost immediately. THC rapidly passes from the lungs into the bloodstream, which carries the chemical to organs throughout the body, including the brain. The effects of smoked marijuana can last from 1 to 3 hours. If marijuana is consumed in foods or beverages, the effects appear later—usually in 30 minutes to 1 hour—but can last up to 4 hours. Smoking marijuana delivers significantly more THC into the bloodstream than eating or drinking the drug.

Marijuana's Effects on the Brain



When marijuana is smoked, its active ingredient, THC, travels throughout the body, including the brain, to produce its many effects. THC attaches to sites called cannabinoid receptors on nerve cells in the brain, affecting the way those cells work. Cannabinoid receptors are abundant in parts of the brain that regulate movement, coordination, learning and memory, higher cognitive functions such as judgment, and pleasure.

Scientists have learned a great deal about how THC acts in the brain. THC binds to specific sites called *cannabinoid receptors* (CBRs) located on the surface of nerve cells. These receptors are found in high-density in areas of the brain that influence pleasure, memory, thinking, concentration, movement, coordination, and sensory and time perception. CBRs are part of a vast communication network known as the endocannabinoid system, which plays a critical role in normal brain development and function. In fact, THC effects are similar to those produced by naturally occurring chemicals found in the brain (and body) called *endogenous cannabinoids.* These chemicals help control many of the same mental and physical functions that may be disrupted by marijuana use.

When someone smokes marijuana, THC stimulates the CBRs artificially, disrupting function of the natural, or endogenous, cannabinoids. An overstimulation of these receptors in key brain areas produces the marijuana "high," as well as other effects on mental processes. Over time, this overstimulation can alter the function of CBRs, which, along with other changes in the brain, can lead to addiction and to withdrawal symptoms when drug use stops.

The THC content or potency of marijuana, as detected in confiscated samples over the past 30+ years (Potency Monitoring Project, University of Mississippi), has been steadily increasing. This increase raises concerns that the consequences of marijuana use could be worse than in the past, particularly among new users, or in young people, whose brains are still developing. We still do not know, however, whether cannabis users adjust for the increase in potency by using less or by smoking it differently. We also do not know all the consequences to the brain and body when exposed to higher concentrations of THC.

How Does Marijuana Use Affect Your Brain and Body?

Effects on the Brain

As THC enters the brain, it causes the user to feel euphoric—or high—by acting on the brain's reward system, which is made up of regions that govern the response to pleasurable things like sex and chocolate, as well as to most drugs of abuse. THC activates the reward system in the same way that nearly all drugs of abuse do: by stimulating brain cells to release the chemical dopamine.

Along with euphoria, relaxation is another frequently reported effect in human studies. Other effects, which vary dramati-

Marijuana users who have taken large doses of the drug may experience an acute psychosis, which includes hallucinations, delusions, and a loss of the sense of personal identity.

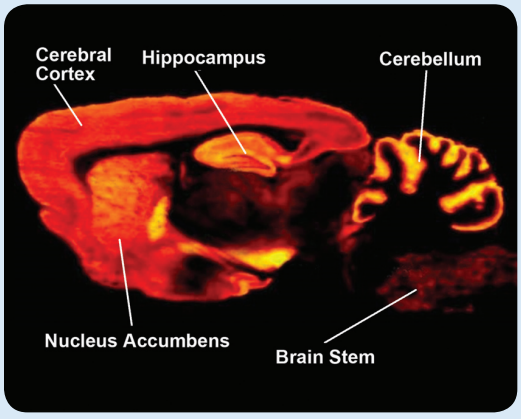
cally among different users, include heightened sensory perception (e.g., brighter colors), laughter, altered perception of time, and increased appetite. After a while, the euphoria subsides, and the user may feel sleepy or depressed. Occasionally, marijuana use may produce anxiety, fear, distrust, or panic.

Marijuana use impairs a person's ability to form new memories **(see below, "Marijuana, Memory, and the Hippocampus")** and to shift focus. THC also disrupts coordination and balance by binding to receptors in the cerebellum and basal ganglia—parts of the brain that regulate balance, posture, coordination, and reaction time. Therefore, learning, doing complicated tasks, participating in athletics, and driving are also affected.

Marijuana users who have taken large doses of the drug may experience an acute psychosis, which includes hallucinations, delusions, and a loss of the sense of personal identity. Although the specific causes of these symptoms remain unknown, they appear to occur more frequently when a high dose of cannabis is consumed in food or drink rather than smoked. Such short-term psychotic reactions to high concentrations of THC are distinct from longer-lasting, schizophrenia-like disorders that have been associated with the use of cannabis in vulnerable individuals. **(See section on the link between marijuana use and mental illness, page 6.)**

Our understanding of marijuana's long-term brain effects is limited. Research findings on how chronic cannabis use affects brain *structure*, for example, have been inconsistent. It may be that the effects are too subtle for reliable detection by current techniques. A similar challenge arises in studies of the effects of chronic marijuana use on brain *function*. Although imaging studies (functional MRI; fMRI) in chronic users do show some consistent alterations, the relation of these changes to cognitive functioning is less clear. This uncertainty may stem from confounding factors such as other drug use, residual drug effects (which can occur for at least 24 hours in chronic users), or withdrawal symptoms in long-term chronic users.

An enduring question in the field is whether individuals who quit marijuana, even after long-term, heavy use, can recover some



Distribution of cannabinoid receptors in the rat brain. Brain image reveals high levels (shown in orange and yellow) of cannabinoid receptors in many areas, including the cortex, hippocampus, cerebellum, and nucleus accumbens (ventral striatum).

Marijuana, Memory, and the Hippocampus

Memory impairment from marijuana use occurs because THC alters how information is processed in the hippocampus, a brain area responsible for memory formation.

Most of the evidence supporting this assertion comes from animal studies. For example, rats exposed to THC in utero, soon after birth, or during adolescence, show notable problems with specific learning/memory tasks later in life. Moreover, cognitive impairment in adult rats is associated with structural and functional changes in the hippocampus from THC exposure during adolescence.

As people age, they lose neurons in the hippocampus, which decreases their ability to learn new information. Chronic THC exposure may hasten age-related loss of hippocampal neurons. In one study, rats exposed to THC every day for 8 months (approximately 30 percent of their lifespan) showed a level of nerve cell loss (at 11 to 12 months of age) that equaled that of unexposed animals twice their age.

of their cognitive abilities. One study reports that the ability of long-term heavy marijuana users to recall words from a list was still impaired 1 week after they quit using, but returned to normal by 4 weeks. However, another study found that marijuana's effects on the brain can build up and deteriorate critical life skills over time. Such effects may be worse in those with other mental disorders, or simply by virtue of the normal aging process.

Effects on General Physical Health

Within a few minutes after inhaling marijuana smoke, an individual's heart rate speeds up, the bronchial passages relax and become enlarged, and blood vessels in the eyes expand, making the eyes look red. The heart rate—normally 70 to 80 beats per minute—may increase by 20 to 50 beats per minute, or may even double in some cases. Taking other drugs with marijuana can amplify this effect.

Limited evidence suggests that a person's risk of heart attack during the first hour after smoking marijuana is four times his or her usual risk. This observation could be partly explained by marijuana raising blood pressure (in some cases) and heart rate and reducing the blood's capacity to carry oxygen. Such possibilities need to be examined more closely, particularly since current marijuana users include adults from the baby boomer generation, who may have other cardiovascular risks that may increase their vulnerability.

The smoke of marijuana, like that of tobacco, consists of a toxic mixture of gases and particulates, many of which are known to be harmful to the lungs. Someone who smokes marijuana regularly may have many of the same respiratory problems that tobacco smokers do, such as daily cough and phlegm production, more frequent acute chest illnesses, and a greater risk of lung infections. Even infrequent marijuana use can cause burning and stinging of the mouth and throat, often accompanied by a heavy cough. One study found that extra sick days used by frequent marijuana smokers were often because of respiratory illnesses (Polen et al. 1993).

In addition, marijuana has the *potential* to promote cancer of the lungs and other parts of the respiratory tract because it contains irritants and carcinogens—up to 70 percent more than tobacco smoke. It also induces high levels

Consequences of Marijuana Abuse

Acute (present during intoxication)

- Impairs short-term memory
- Impairs attention, judgment, and other cognitive functions
- Impairs coordination and balance
- Increases heart rate
- Psychotic episodes

Persistent (lasting longer than intoxication, but may not be permanent)

- Impairs memory and learning skills
- Sleep impairment

Long-term (cumulative effects of chronic abuse)

- Can lead to addiction
- Increases risk of chronic cough, bronchitis
- Increases risk of schizophrenia in vulnerable individuals
- May increase risk of anxiety, depression, and amotivational syndrome*

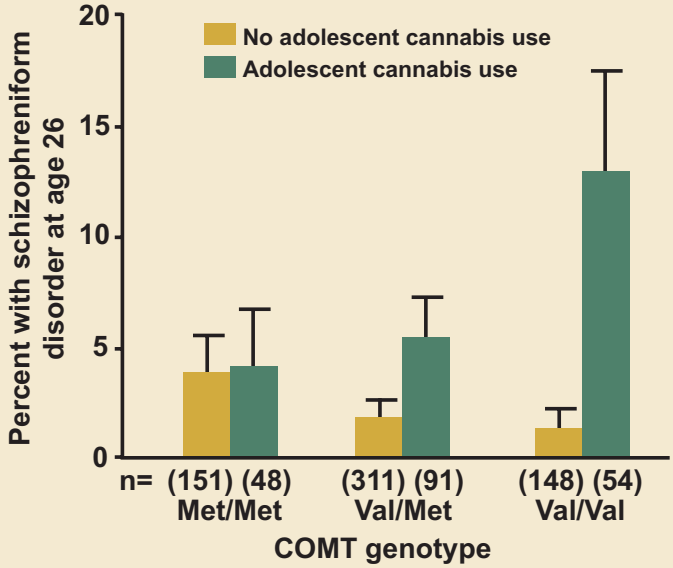
*These are often reported co-occurring symptoms/disorders with chronic marijuana use. However, research has not yet determined whether marijuana is causal or just associated with these mental problems.

Within a few minutes after inhaling marijuana smoke, an individual's heart rate speeds up, the bronchial passages relax and become enlarged, and blood vessels in the eyes expand, making the eyes look red.

of an enzyme that converts certain hydrocarbons into their cancer-causing form, which could accelerate the changes that ultimately produce malignant cells. And since marijuana smokers generally inhale more deeply and hold their breath longer than tobacco smokers, the lungs are exposed longer to carcinogenic smoke. However, while several lines of evidence have suggested that marijuana use may lead to lung cancer, the supporting evidence is inconclusive (Hashibe et al. 2006). The presence of an unidentified active ingredient in cannabis smoke having protective properties—if corroborated and properly characterized—could help explain the inconsistencies and modest findings.

A significant body of research demonstrates negative effects of THC on the function of various immune cells, both in vitro in cells and in vivo with test animals. However, no studies to date connect marijuana's suspected immune system suppression with greater incidence of infections or immune disorders in humans. One short (3-week) study found marijuana smoking to be associated with a few statistically significant negative effects on the immune function of AIDS patients; a second small study of college students also suggested the possibility of marijuana having adverse effects on immune system functioning. Thus, the combined evidence from animal studies plus the limited human data available, seem to warrant additional research on the impact of marijuana on the immune system. **(See also "The Science of Medical Marijuana," page 9.)**

Genetic variation in COMT influences the harmful effects of abused drugs



Adapted from Caspi et al., *Biol Psychiatry*, May 2005.

The influence of adolescent marijuana use on adult psychosis is affected by genetic variables. This figure shows that variations in a gene can affect the likelihood of developing psychosis in adulthood, following exposure to cannabis in adolescence. The COMT gene governs an enzyme that breaks down dopamine, a brain chemical involved in schizophrenia. It comes in two forms: "Met" and "Val." Individuals with one or two copies of the Val variant have a higher risk of developing schizophrenic-type disorders if they used cannabis during adolescence (dark bars). Those with only the Met variant were unaffected by cannabis use.

Is There a Link Between Marijuana Use and Mental Illness?

Research in the past decade has focused on whether marijuana use actually causes other mental illnesses. The strongest evidence to date suggests a link between cannabis use and psychosis (Hall and Degenhardt 2009). For example, a series of large prospective studies that followed a group of people over time showed a relationship between marijuana use and later development of psychosis. Marijuana use also worsens the course of illness in patients with schizophrenia and can produce a brief psychotic reaction in some users that fades as the drug wears off. The amount of drug used, the age at first use, and genetic vulnerability can all influence this relationship. One example is a study **(illustrated, page**

6) that found an increased risk of psychosis among adults who had used marijuana in adolescence *and* who also carried a specific variant of the gene for catechol-O-methyltransferase (COMT) (Caspi et al. 2005), an enzyme that degrades neurotransmitters such as dopamine and norepinephrine.

In addition to the observed links between marijuana use and schizophrenia, other less consistent associations have been reported between marijuana use and depression, anxiety, suicidal thoughts among adolescents, and personality disturbances. One of the most frequently cited, albeit still controversial, is an amotivational syndrome, defined as a diminished or absent drive to engage in typically rewarding activities. Because of the role of the endocannabinoid system in regulating mood, these associations make a certain amount of sense; however, more research is needed to confirm and better understand these linkages.

Is Marijuana Addictive?

Long-term marijuana use can lead to addiction; that is, people have difficulty controlling their drug use and cannot stop even though it interferes with many aspects of their lives. It is estimated that 9 percent of people who use marijuana will become dependent on it. The number goes up to about 1 in 6 in those who start using young (in their teens) and to 25–50 percent among daily users. Moreover, a study of over 300 fraternal and identical twin pairs

found that the twin who had used marijuana before the age of 17 had elevated rates of other drug use and drug problems later on, compared with their twin who did not use before age 17.

According to the 2008 NSDUH, marijuana accounted for 4.2 million of the estimated 7 million Americans dependent on or abusing illicit drugs. In 2008, approximately 15 percent of people entering drug abuse treatment programs reported marijuana as their primary drug of abuse; 61 percent of persons under 15 reported marijuana as their primary drug of abuse, as did 56 percent of those 15 to 19 years old.

Marijuana addiction is also linked to a withdrawal syndrome similar to that of nicotine withdrawal, which can make it hard to quit. People trying to quit report irritability, sleeping difficulties, craving, and anxiety. They also show increased aggression on psychological tests, peaking approximately 1 week after they last used the drug.

How Does Marijuana Use Affect School, Work, and Social Life?

Research has shown that marijuana's negative effects on attention, memory, and learning can last for days or weeks after the acute effects of the drug wear off (Schweinsburg et al. 2008). Consequently, someone who smokes marijuana daily may be functioning at a reduced intellectual level most or all of the time. Not surprisingly, evidence suggests that, compared with their nonsmoking peers, students who smoke marijuana tend to get lower grades and are more likely to drop out of high school (Fergusson and Boden 2008). A meta-analysis of 48 relevant studies—one of the most thorough performed to date—found cannabis use to be associated consistently with reduced educational attainment (e.g., grades and chances of graduating) (Macleod et al. 2004). However, a *causal* relationship is not yet proven between cannabis use by young people and psychosocial harm.

That said, marijuana users themselves report poor outcomes on a variety of life satisfaction and achievement measures. One study compared current and former long-term heavy users of marijuana with a control group who reported smoking cannabis at least once in their lives but not more than 50 times. Despite similar education and income backgrounds, significant differences were found in educational attainment: fewer of the heavy users of cannabis com-

pleted college, and more had yearly household incomes of less than $30,000. When asked how marijuana affected their cognitive abilities, career achievements, social lives, and physical and mental health, the majority of heavy cannabis users reported the drug's negative effects on all of these measures. In addition, several studies have linked workers' marijuana smoking with increased absences, tardiness, accidents, workers' compensation claims, and job turnover. For example, a study among postal workers found that employees who tested positive for marijuana on a pre-employment urine drug test had 55 percent more industrial accidents, 85 percent more injuries, and a 75-percent increase in absenteeism compared with those who tested negative for marijuana use.

Does Marijuana Use Affect Driving?

Because marijuana impairs judgment and motor coordination and slows reaction time, an intoxicated person has an increased chance of being involved in and being responsible for an accident (O'Malley and Johnston 2007; Richer and Bergeron 2009). According to the National Highway Traffic Safety Administration, drugs other than alcohol (e.g., marijuana and cocaine) are involved in about 18 percent of motor vehicle driver deaths. A recent survey found that 6.8 percent of drivers, mostly under 35, who were involved in accidents tested positive for THC; alcohol levels above the legal limit were found in 21 percent of such drivers.

Can Marijuana Use During Pregnancy Harm the Baby?

Animal research suggests that the body's endocannabinoid system plays a role in the control of brain maturation, particularly in the development of emotional responses. It is conceivable that even low concentrations of THC, when administered during the perinatal period, could have profound and long-lasting consequences for both brain and behavior (Trezza et al. 2008). Research has shown that some babies born to women who used marijuana during their pregnancies display altered responses to visual stimuli, increased tremulousness, and a high-pitched cry, which could indicate problems with neurological development. In school, marijuana-exposed children are more likely to show gaps in problemsolving skills, memory, and the ability to remain attentive. More research is needed, however, to disentangle the drug-specific factors from the environmental ones (Schempf and Strobino 2008).

Available Treatments for Marijuana Use Disorders

Marijuana dependence appears to be very similar to other substance dependence disorders, although the long-term clinical outcomes may be less severe. On average, adults seeking treatment for marijuana abuse or dependence have used marijuana nearly every day for more than 10 years and have attempted to quit more than six times. It is important to note that marijuana dependence is most prevalent among patients suffering from other psychiatric disorders, particularly among adolescent and young adult populations (Gouzoulis-Mayfrank 2008). Also, marijuana abuse or dependence typically co-occurs with use of other drugs, such as cocaine and alcohol. Available studies indicate that effectively treating the mental health disorder with standard treatments involving medications and behavioral therapies may help reduce cannabis use, particularly among heavy users and those with more chronic mental disorders. Behavioral treatments, such as motivational enhancement therapy (MET), group or individual cognitive-behavioral therapy (CBT), and contingency management (CM), as well as family-based treatments, have shown promise.

Unfortunately, the success rates of treatment are rather modest. Even with the most effective treatment for adults, only about 50 percent of enrollees achieve an initial 2-week period of abstinence, and among those who do, approximately half will resume use within a year. Across studies, 1-year abstinence rates have ranged between 10 and 30 percent for the various behavioral approaches. As with other addictions, these data suggest that a chronic care model should be considered for marijuana addiction, with treatment intensity stepped up or down based on need, comorbid addictions or other mental disorders, and the availability of family and other supports.

Currently, no medications are available to treat marijuana abuse, but research is active in this area. Most of the studies to date have targeted the marijuana withdrawal syndrome. For example, a recent human laboratory study showed that a combination of a cannabinoid agonist medication with lofexidine (a medication approved in the United Kingdom for the treatment of opioid withdrawal) produced more robust improvements in sleep and decreased marijuana withdrawal, craving, and relapse in daily marijuana smokers relative to either medication alone. Recent discoveries about the inner workings of the endogenous cannabinoid system raise the future possibility of a medication able to block THC's intoxicating effects, which could help prevent relapse by reducing or eliminating marijuana's appeal.

The Science of Medical Marijuana

The potential medicinal properties of marijuana have been the subject of substantive research and heated debate. Scientists have confirmed that the cannabis plant contains active ingredients with therapeutic potential for relieving pain, controlling nausea, stimulating appetite, and decreasing ocular pressure. As a result, a 1990 Institute of Medicine report concluded that further clinical research on cannabinoid drugs and safe delivery systems was warranted.

At that time, dronabinol (Marinol®) and nabilone (Cesamet®) were the only FDA-approved, marijuana-based medications that doctors could prescribe for the treatment of nausea in patients undergoing cancer chemotherapy and to stimulate appetite in patients with wasting syndrome due to AIDS. These pills contained synthetic versions of THC, the main active ingredient in marijuana. Today, 25 years after their approval, the development of Sativex® marks the arrival of the second generation of cannabis-based medications. This new product (currently available in the United Kingdom and Canada) is a chemically pure mixture of plant-derived THC and Cannabidiol, formulated as a mouth spray and approved for the relief of cancer-associated pain and spasticity and neuropathic pain in multiple sclerosis.

Scientists continue to investigate the medicinal properties of THC and other cannabinoids to better evaluate and harness their ability to help patients suffering from a broad range of conditions, while avoiding the adverse effects of smoked marijuana. These efforts are bound to improve our understanding of the cannabinoid system and help us bring to market a new generation of safe and effective medications.

Glossary

Addiction: A chronic, relapsing disease characterized by compulsive drug seeking and use and by long-lasting changes in the brain.

Basal Ganglia: Structures located deep in the brain that play an important role in the initiation of movements. These clusters of neurons include the caudate nucleus, putamen, globus pallidus, and substantia nigra. It also contains the nucleus accumbens, which is the main center of reward in the brain.

Cerebellum: A large structure located in the back of the brain that helps control the coordination of movement by making connections to other parts of the CNS (pons, medulla, spinal cord, and thalamus). It also may be involved in aspects of motor learning.

Cerebral Cortex: The outermost layer of the cerebral hemispheres of the brain. It is largely responsible for conscious experience, including perception, emotion, thought, and planning.

Cannabinoids and Cannabinoid Receptors: A family of chemicals that bind to specific (cannabinoid) receptors to influence mental and physical functions. Cannabinoids that are produced naturally by the body are referred to as endocannabinoids. They play important roles in development, memory, pain, appetite, among others. The marijuana plant *(Cannabis sativa)* contains delta-9-tetrahydrocannabinol (THC) that can disrupt these processes, if administered repeatedly and/or in high enough concentrations.

Carcinogen: Any substance that causes cancer.

Cognitive-Behavioral Therapy (CBT): A form of psychotherapy that teaches people strategies to identify and correct problematic behaviors in order to enhance self-control, stop drug use, and address a range of other problems that often co-occur with them.

Contingency Management (CM): A therapeutic management approach based on frequent monitoring of the target behavior and the provision (or removal) of tangible, positive rewards when the target behavior occurs (or does not). CM techniques have shown to be effective for keeping people in treatment and promoting abstinence.

Dopamine: A brain chemical, classified as a neurotransmitter, found in regions of the brain that regulate movement, emotion, motivation, and pleasure.

Hippocampus: A seahorse-shaped structure located within the brain that is considered an important part of the limbic system. One of the most studied areas of the brain, the hippocampus plays key roles in learning, memory, and emotion.

Hydrocarbon: Any chemical compound containing only hydrogen and carbon.

Motivational Enhancement Therapy (MET): A systematic form of intervention designed to produce rapid, internally motivated change. MET does not attempt to treat the person, but rather mobilize their own internal resources for change and engagement in treatment.

Psychosis: A mental disorder (e.g., schizophrenia) characterized by delusional or disordered thinking detached from reality; symptoms often include hallucinations.

Schizophrenia: A psychotic disorder characterized by symptoms that fall into two categories: (1) positive symptoms, such as distortions in thoughts (delusions), perception (hallucinations), and language and thinking and (2) negative symptoms, such as flattened emotional responses and decreased goal-directed behavior.

Schizophreniform Disorders: Similar to schizophrenia, but of shorter duration and possibly lesser severity.

THC: Delta-9-tetrahydrocannabinol; the main active ingredient in marijuana, which acts on the brain to produce its effects.

Ventral Striatum: An area of the brain that is part of the basal ganglia and becomes activated and flooded with dopamine in the presence of salient stimuli. The release of this chemical also occurs during physically rewarding activities such as eating, sex, and taking drugs, and is a key factor behind our desire to repeat these activities.

Withdrawal: Adverse symptoms that occur after chronic use of a drug is reduced or stopped.

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Where Can I Get More Scientific Information on Marijuana Abuse?

To learn more about marijuana and other drugs of abuse, or to order materials on these topics free of charge in English or Spanish, visit the NIDA Web site at **www.drugabuse.gov** or contact the *DrugPubs* Research Dissemination Center at 877-NIDA-NIH (877-643-2644; TTY/TDD: 240-645-0228).

NIDA DRUGPUBS RESEARCH DISSEMINATION CENTER

What's New on the NIDA Web Site

- Information on drugs of abuse
- Publications and communications (including *NIDA Notes* and *Addiction Science & Clinical Practice journal*)
- Calendar of events
- Links to NIDA organizational units
- Funding information (including program announcements and deadlines)
- International activities
- Links to related Web sites (access to Web sites of many other organizations in the field)

NIDA Web Sites

drugabuse.gov
backtoschool.drugabuse.gov
marijuana-info.org
teens.drugabuse.gov

For Physician Information

NIDAMED

www.drugabuse.gov/nidamed

Other Web Sites

Information on marijuana abuse is also available through the following Web site:

- Substance Abuse and Mental Health Services Administration Health Information Network: *www.samhsa.gov/shin*

U.S. Department of Health and Human Services

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